Getting Started with Generative AI: A Guide for Engineering Educators

Practical strategies for integrating generative AI into engineering education

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Overview

This presentation provides:

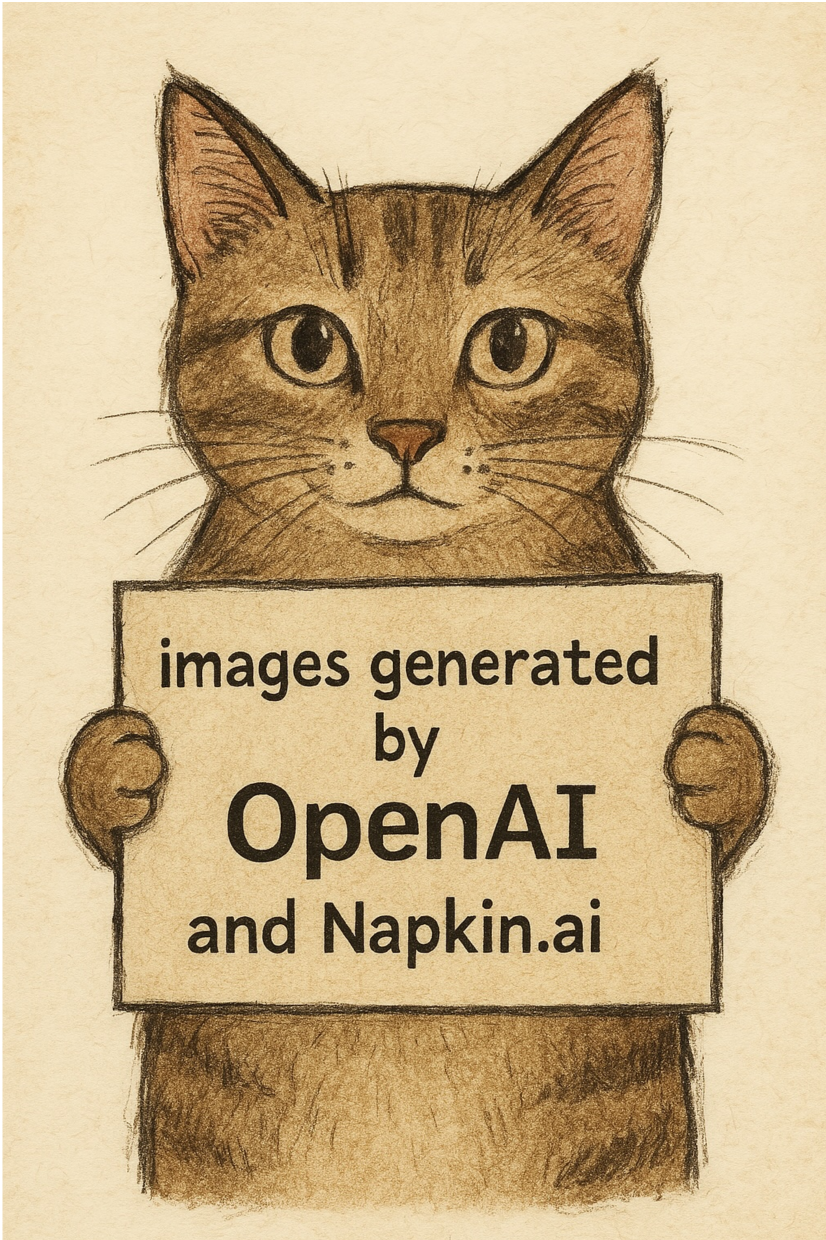
- A foundational understanding of generative AI for engineering education
- Practical guidance for getting started with AI tools
- Strategies for effective implementation in engineering courses
- Resources for further exploration

What We'll Cover

1. Understanding AI in Engineering Education
2. The Six Dimensions of AI Integration
3. Selecting Your First AI Tools
4. Practical First Steps with AI
5. Engineering-Specific Prompting Strategies
6. Addressing Common Concerns
7. Planning Your First AI Activity
8. Implementation Resources

Warmup and a Disclaimer

- The materials for this workshop are available at ideeaslab.com/resources/teaching
- I will use "generative AI" to refer to all AI tools that can generate text, images, code, and other artifacts
- I will also interchangeably refer to "generative AI" and "LLMs" and "AI", though these are not exactly the same thing
- These slides were made with input from Claude-3.7 Sonnet and AI-generated images



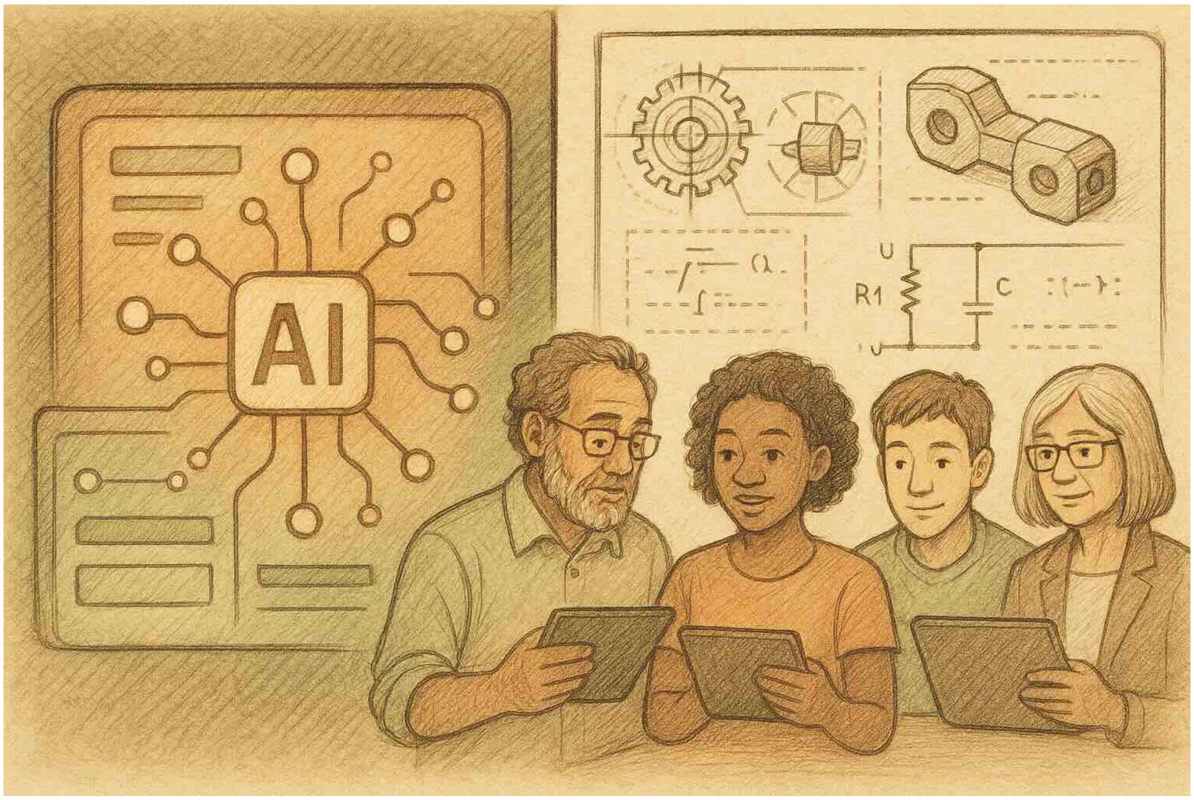
Understanding AI in Engineering Education

What is Generative AI?

AI systems that **create new content** based on patterns in training data

For engineering education, AI can:

- Generate concept explanations
- Create example problems
- Assist with code development
- Produce visualizations
- Help design systems
- Provide personalized feedback



Why Consider AI in Engineering Courses?

Addressing specific challenges in engineering education:

- **Technical Complexity**: Alternative explanations for difficult concepts
- **Visualization Needs**: Visual representations of abstract phenomena
- **Repetitive Calculations**: Focus on deeper analysis, not routine work
- **Diverse Applications**: Connect theory to varied real-world contexts
- **Personalized Feedback**: Individualized guidance at scale

Current Limitations to Consider

- **Technical Accuracy**
  Errors in calculations or outdated information
- **Specialized Knowledge**
  Limited depth in highly specialized topics
- **Visualization Limitations**
  Complex systems may require specialized tools
- **Verification Needs**
  Human verification for safety-critical applications
- **Ethical Considerations**
  Attribution, bias, and appropriate use

Discipline-Specific Considerations

Engineering Discipline	Key AI Opportunities	Special Considerations
Civil	Structural analysis, code compliance	Safety-critical verification
Mechanical	Thermodynamics visualization, CAD	Simulation limitations
Electrical	Circuit analysis, signal processing	Component detail accuracy
Chemical	Reaction pathways, process optimization	Safety considerations
Computer	Code generation, algorithms	Code quality evaluation

The Six Dimensions of AI Integration

AI Integration Taxonomy

A framework for thinking about AI integration in your courses:

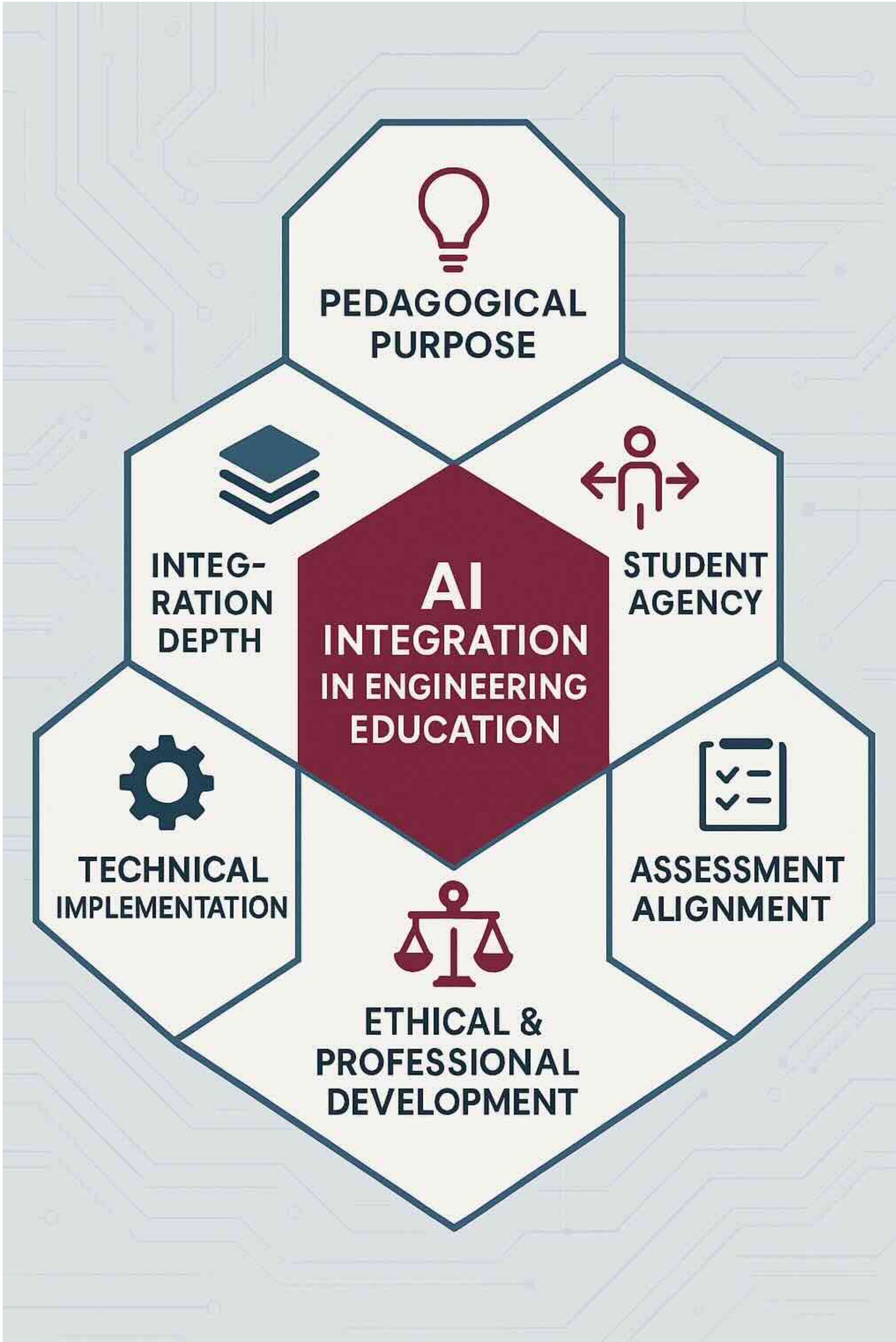


Figure 1: AI Integration Taxonomy - 6 dimensions

Dimension 1: Pedagogical Purpose

Ask yourself: What learning challenges am I trying to address?

- **Conceptual Understanding**
  Explaining difficult engineering concepts
- **Skill Development**
  Bypassing technical hurdles
- **Process Augmentation**
  Enhancing engineering workflows
- **Content Creation**
  Generating educational materials
- **Visualization**
  Representing complex phenomena

Dimension 2: Integration Depth

Ask yourself: How central will AI be to course activities?

- **Supplemental Resource**
  Optional tools outside core instruction
- **Guided Integration**
  Structured prompts for specific activities
- **Embedded Practice**
  AI integrated throughout coursework
- **Transformative Redesign**
  Course restructured around AI capabilities

Dimensions 3-4: Student Agency & Assessment

Student Agency
How much control will students have?

- Instructor-Directed
- Scaffolded Autonomy
- Guided Exploration
- Full Autonomy

Assessment Alignment
How will you evaluate learning?

- Process Documentation
- Comparative Analysis
- Critical Evaluation
- Meta-Learning
- AI-Restricted Components

Dimensions 5-6: Technical & Ethical

Technical Implementation
What practical aspects need consideration?

- Tool Selection
- Access Provision
- Prompt Engineering
- Error Management
- Integration Infrastructure

Ethical & Professional Development
How will you address responsible use?

- Attribution Practices
- Professional Norms
- Critical AI Literacy
- Responsible Use
- Equity Considerations

Selecting Your First AI Tools

General-Purpose AI Tools

ChatGPT (OpenAI)

- Text generation, code assistance
- Free tier available
- Widely used, versatile
- Strengths: Code, general explanations

Claude (Anthropic)

- Detailed explanations, reasoning

- Free tier with generous limits
- Excellent for complex concepts
- Strengths: Longer context, reasoning

Gemini (Google)

- Visual processing, research info
- Free tier available
- Strong math capabilities
- Strengths: Math, recent research

Copilot (GitHub)

- Code generation, programming
- Subscription; edu access available
- Engineering programming focus
- Strengths: Code-specific tasks

Setting Up Your First Tool

ChatGPT Quick Start

1. Visit chat.openai.com
2. Create account (use institutional email)
3. Start with free GPT-4o
4. Explore interface and capabilities

Claude Quick Start

1. Visit claude.ai
2. Create account
3. Try Claude 3.5-Haiku for basics
4. Try Claude 3.7-Sonnet for advanced needs

Choosing Your First Tool

> Tip
>
> **Recommendation**: Start with **ChatGPT** or **Claude** due to:
>
> - Versatility across multiple engineering applications
> - Accessibility without specialized setup
> - Strong user communities for support

- Free access tiers sufficient for exploration
- Balance of capabilities for engineering tasks

Practical First Steps with AI Tools

Before You Begin

1. **Create an account** with your institutional email
2. **Set aside 30-60 minutes** for uninterrupted exploration
3. **Have engineering materials handy** (concepts, problems, etc.)
4. **Start with low stakes exploration** rather than production content
5. **Try multiple prompts** on the same topic to compare approaches

Activity 1: Concept Explanation

Note

Ask AI to explain an engineering concept in multiple ways:

```
Explain the concept of control system stability in three different ways:
1. To a first-year engineering student
2. Using a real-world analogy
3. With connections to related engineering principles

Include any limitations in your explanation that engineers
should be aware of.
```

Activity 2: Problem Generation

Note

Generate practice problems similar to ones you already use:

```
Generate three practice problems on fluid mechanics at the
junior undergraduate level in mechanical engineering.

For each problem:
1. State the problem clearly
```

```
2. Provide the solution with step-by-step work
3. Highlight common student misconceptions related to this type of problem
```

Activity 3: Visual Explanation

> **Note**
>
> Request visualization descriptions for complex concepts:
>
> ```
> Describe how to visualize stress distribution in a loaded beam
> in a way that would help students understand the underlying principles.
>
> Be specific about what elements should be included in this visualization
> and how they relate to the mathematical or physical principles involved.
> ```

Activity 4: Prompt Analysis

> **Note**
>
> Get feedback on your own prompting approach:
>
> ```
> Please analyze the effectiveness of my previous prompt.
> What elements of my prompt led to useful responses?
> What could I improve to get better information for
> engineering education purposes?
> ```

Engineering-Specific Prompting Strategies

Key Elements of Effective Engineering Prompts

Technical Parameters

```
I need an explanation of fluid flow in a pipe with:
- 2-inch diameter
- Reynolds number of approximately 2500
- Water at 20°C as the fluid
```

Educational Context

```
I'm teaching this to junior mechanical
engineering students who have completed:
- Fluid Mechanics I
- Thermodynamics
- Differential Equations
```

Multiple Perspectives

```
Please explain this concept from:
- A mathematical perspective
- A physical/intuitive perspective
- An applications perspective
```

Limitations Request

```
What are the limitations or edge cases
where this explanation breaks down?
What simplifying assumptions are being made?
```

Prompt Structure Template

> **Tip**
>
> ```
> I need help with [specific engineering task].
>
> Context:
> - [Course level and discipline]
> - [Relevant prerequisites]
> - [Specific applications or focus]
>
> Requirements:
> - [Technical parameters]
> - [Desired format]
> - [Level of detail]
>
> Additional considerations:
> - [Limitations to address]
> - [Connections to make]
> ```

```
- [Common misconceptions]
```

Civil Engineering Example

> **Note**

```
I need an explanation of moment distribution in statically indeterminate structures.

Context:
- This is for a junior-level structural analysis course
- Students have completed statics and mechanics of materials
- Focus on building frames and continuous beams

Requirements:
- Include both the mathematical process and physical interpretation
- Show a step-by-step example with a two-span continuous beam
- Highlight the connection between moment diagrams and deflected shapes

Additional considerations:
- Address the limitation of hand calculations vs. computer analysis
- Connect to practical applications in building design
- Address common sign convention confusion
```

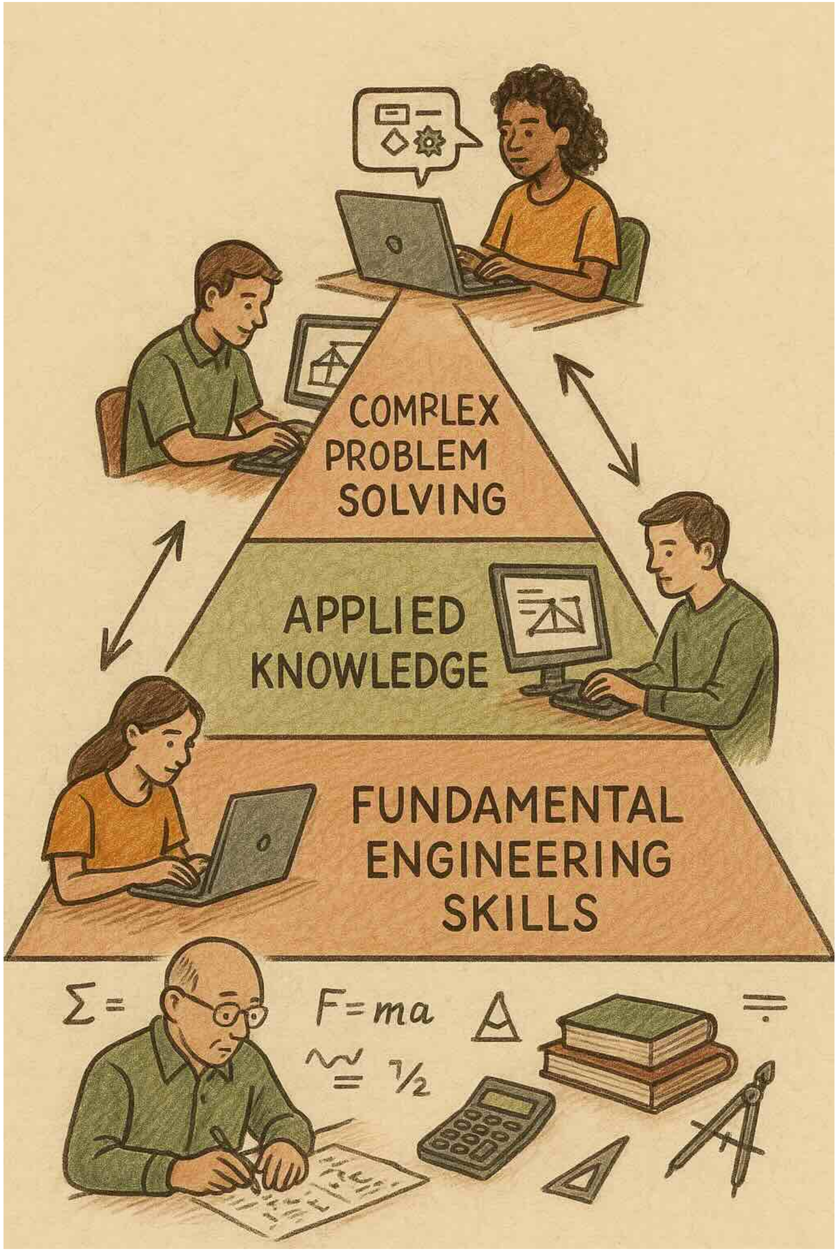
Addressing Common Concerns

"Will students still learn fundamental skills?"

Strategy: Use a layered approach - teach fundamentals first, then introduce AI tools.

Example: In circuits course, have students manually solve basic problems first, then use AI for complex circuits with verification.

Assessment Connection: Measure both foundational skills and AI-enhanced capabilities separately.



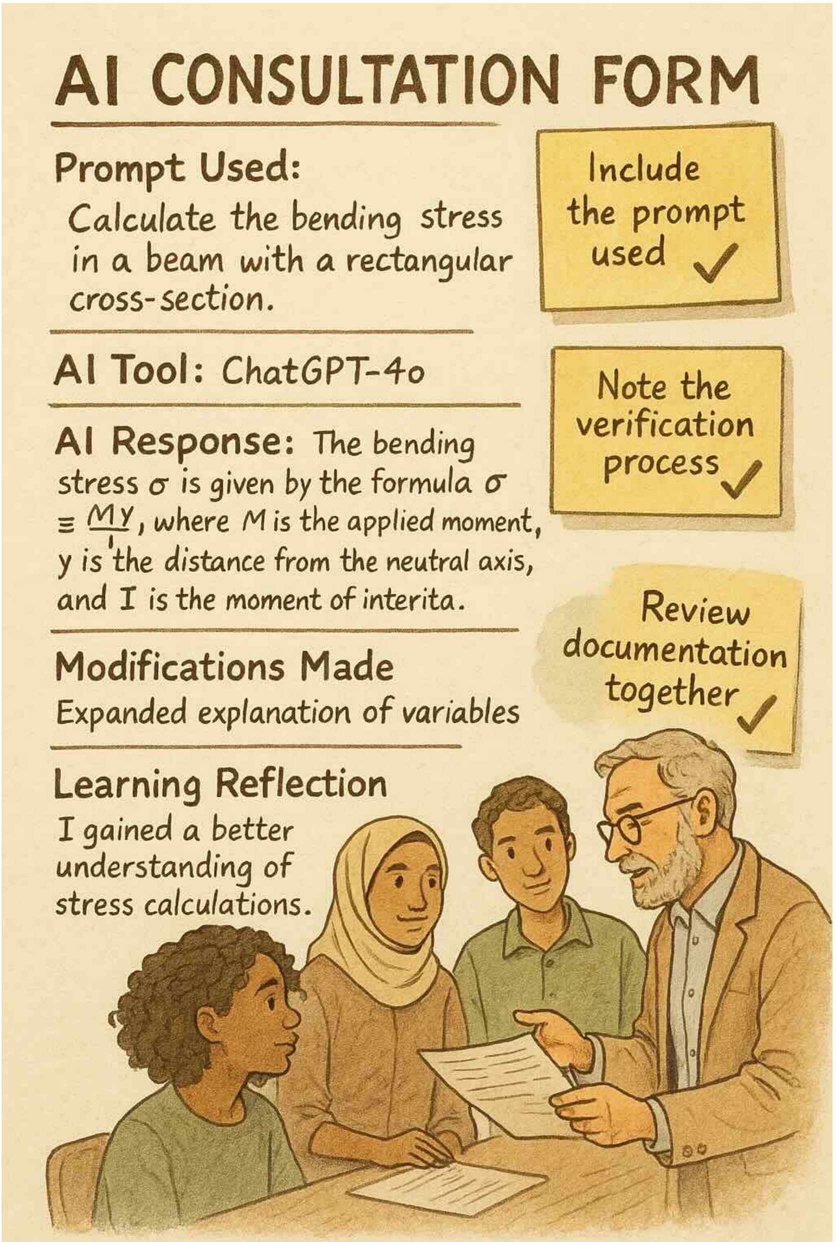
"How do I ensure academic integrity?"

Strategy: Shift from "preventing AI use" to "requiring appropriate AI use" with documentation.

Example: Create "AI Consultation Forms" documenting:

- Prompts used
- AI responses
- Evaluation of accuracy
- Modifications made

Assessment Connection: Make documentation part of assessment criteria, evaluating critical thinking about AI outputs.

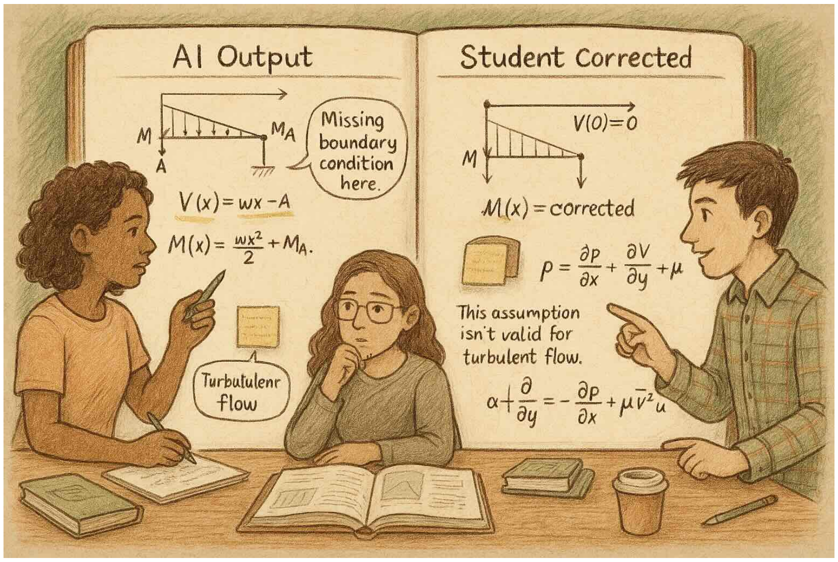


“What if the AI provides incorrect information?”

Strategy: Use this as a teaching opportunity for critical evaluation.

Example: Provide challenging problems where the AI likely makes simplifying assumptions. Guide students to identify limitations.

Assessment Connection: Include ability to identify and correct AI errors as a learning outcome with assessment criteria.

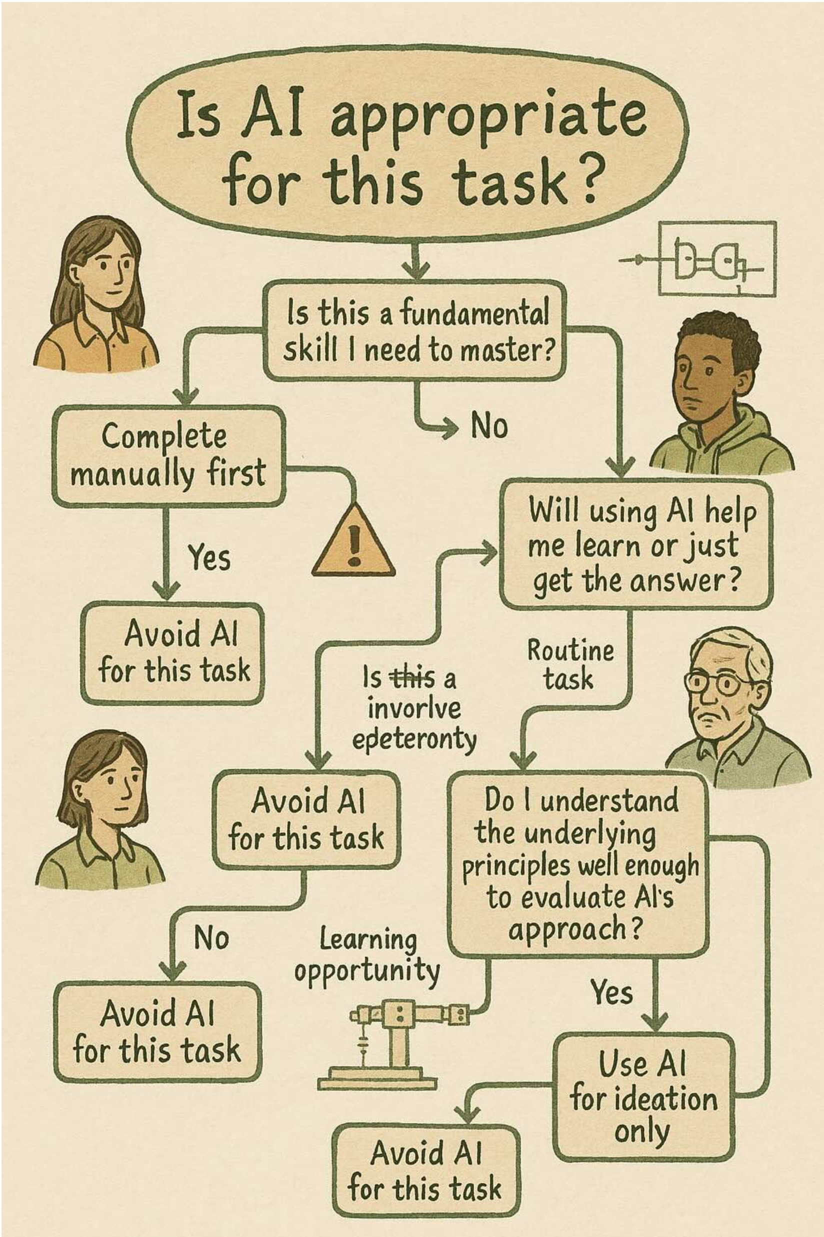


“Will students become dependent on AI?”

Strategy: Focus on AI as a tool requiring engineering judgment, not a replacement for expertise.

Example: Have students compare different AI tools’ approaches to the same problem, analyzing differences and determining validity.

Assessment Connection: Develop metacognitive assessments measuring understanding of when AI is appropriate vs. when other approaches are needed.



Planning Your First AI-Enhanced Activity

Three Steps to Effective Implementation

1. **Start Small**

- Single, bounded activity where AI adds value
- Focus on difficult concepts, design brainstorming, or feedback

2. **Define Specific Learning Objectives**
   - Focus on critical evaluation, efficiency, error identification
   - Connect to existing course objectives
3. **Create Clear Student Instructions**
   - Specify tool options, provide prompting guidance
   - Include verification and documentation requirements

Sample Activity: Problem Analysis

Note

```
AI-Enhanced Problem Analysis Activity

Preparation:
1. Choose one of the provided AI tools (ChatGPT, Claude, or Gemini)
2. Have your completed solution to Problem 3.5 available for reference

Instructions:
1. Submit Problem 3.5 to your chosen AI tool with the prompt:
   "Please solve this engineering problem step by step,
   explaining your reasoning at each stage."
2. Compare the AI solution to your own solution, noting:
   - Any differences in approach
   - Steps where the AI excelled or struggled
   - Assumptions made by the AI
   - Errors or limitations in the AI solution
3. Submit a 1-page analysis addressing:
   - Which solution method is more appropriate and why
   - What the AI missed or simplified
   - How you would improve the AI's approach
   - How this tool might be useful in your future engineering work
```

Sample Activity: Concept Visualization

> **Note**

```
Thermal Gradient Visualization Activity

Learning Objectives:
- Visualize abstract thermal concepts spatially
- Connect mathematical expressions to physical phenomena
- Identify limitations in simplified thermal models

Instructions:
1. Choose a thermal system we've studied (heat exchanger, engine, HVAC component)
2. Use Claude to generate descriptions of how temperature gradients develop in your system
3. Use DALL-E to create visualizations based on these descriptions
4. Analyze the visualizations for accuracy and limitations
5. Prepare a brief presentation explaining:
   - Key thermal principles illustrated
   - How the visualization helps understanding
   - Technical limitations of the AI-generated visualization
   - How you would improve the visualization
```

Implementation Resources

Implementation Checklist

Preparation

- ☐ Tested the activity yourself
- ☐ Identified potential limitations
- ☐ Created verification strategies
- ☐ Developed clear instructions
- ☐ Aligned with institutional policies

Learning Design

- ☐ Defined learning objectives
- ☐ Connected to disciplinary practices
- ☐ Determined student guidance level
- ☐ Created documentation requirements
- ☐ Designed assessment approach

Implementation Checklist (continued)

Technical Considerations

- ☐ Ensured AI tools are accessible
- ☐ Provided alternatives for failures
- ☐ Considered data privacy aspects
- ☐ Created support mechanism

Assessment

- ☐ Determined assessment criteria
- ☐ Created clear rubrics
- ☐ Planned for feedback collection
- ☐ Considered academic integrity
- ☐ Designed for metacognitive reflection

Sample Syllabus Language

> Tip
>
> **Basic AI Policy Statement**
>
> ```
> Artificial Intelligence Tools in This Course
>
> This course recognizes the increasing role of AI tools in engineering practice.
> Students are permitted to use AI tools with the following guidelines:
>
> 1. Transparency: All use of AI tools must be documented according to the
>    course AI Documentation Guidelines.
>
> 2. Verification: Students are responsible for verifying all AI-generated
>    content for accuracy and appropriateness.
>
> 3. Learning Primacy: AI tools should support, not replace, your learning.
>    Some assignments will be designated as "AI-restricted" to ensure
>    development of fundamental skills.
>
> 4. Academic Integrity: Undocumented use of AI tools will be considered an
>    academic integrity violation. When in doubt, document your use.
> ```

Resources for Further Learning

Case Studies

- Thermodynamics with ChatGPT
- Mechanical Engineering Design with ChatGPT
- Programming Courses with GitHub Copilot
- Materials Science with Claude
- Circuit Analysis with Claude

Implementation Planning

- Course-Level Implementation Plan
- AI Assignment Design Template
- Case Study Analysis Worksheet

Prompting Resources

- Engineering-Specific Prompts
- AI Prompt Engineering Guide

Workshop Materials

- Prompt Engineering Challenge
- Designing Effective AI Assignments

Assessment Resources

- AI Literacy Rubric Framework
- Assessment Design in the Age of AI
- Documenting AI Use

Thank You!

Next Steps:

- Download our Faculty Getting Started Guide
- Keep a look out for our engineering education AI community
- Try one activity in your own course
- Share your experiences and insights

Contact us: akatz4@vt.edu